HOLYOKEITE, A PURELY FELDSPATHIC DIABASE FROM THE TRIAS OF MASSACHUSETTS.[1]

In the monograph of the three river counties in Massachusetts,[2] the writer described a "white trap" which occurs only in scanty fragments in a bed of agglomerate interstratified in the sandstone, a few feet above the surface of the great Holyoke trap sheet at the east foot of Mount Tom, and a few rods north of the station of the electric road going up onto the mountain. The small angular fragments of the volcanic rock are scattered rather distantly in the calcareous red sandstone, and seem closely like a white, horny limestone spotted with chalcopyrite. They include fragments of the coarse sandstone below the Holyoke trap sheet, up through which they must have come, and these inclusions are much coarser than the sandstone in which they are included. The weathered surfaces show the rock to be finely amygdaloidal, and acid brings out in the interior the same structure which can indeed be seen, by attentive study with a lens, on a freshly broken surface. A few grains of yellow ore appear here and there in the body of the rock and in the round cavities, and rarely the reflection of a twinned plagioclase lath is visible.

The thin section shows so exactly every structure of the diabase except those dependent upon the presence of iron in form of magnetite and augite that one cannot help associating it closely with the adjacent Holyoke sheet, as I have formerly done by calling it a "white trap." Even the presence of much chalcopyrite is characteristic. Under the microscope the texture is exactly that of the trap of the large sheets minus the augite. It is especially like the superficial portion of the Deerfield sheet exposed at Cheapside.

There is an ophitic network of very fine plagioclase needles

[1] Published by permission of the director of the United States Geological Survey.

[2] *Monograph XXIX, U. S. Geol. Surv.*, 1898, pp. 365–474.

of two sizes, both elongate blades with ragged ends and irregular sides; the finer about 0.03^{mm} long; the latter having sometimes quite regular crystalline outlines. Scattered in this network are distant feathery groups of plagioclase crystals of first consolidation which are just visible to the eye. One of these larger crystals cut parallel to M (010) showed the optical figure of albite.

All these feldspars are lightly dusted with blades and grains of a secondary mineral of low polarization, probably zoisite. And there is a very little granular limonite scattered through the rock, but no accumulation of it, or appearance of any chloritic mineral to indicate the former presence of magnetite and augite or hornblende. There are no brightly polarizing blades that could be referred to a colorless bisilicate.

As in the peculiar red diabase from Cheapside, near Greenfield, described in the monograph[1] above mentioned, the small round steam cavities are lined by a secondary growth of albite in fresh limpid crystals.

There are other fragments associated with the Holyokeite which are black, aphanitic, and show under the microscope a similar texture, but contain large spots of a green chloritic mineral.

The chemical composition of the rock is shown by the following analysis I, by Mr. Hillebrand.

If we follow the calculation of the analyst and assign the sulphur to 0.40 chalcopyrite and 0.06 per cent. pyrite, and then calculate the phosphoric acid as apatite, the titanic acid as ilmenite, the potash as orthoclase, and assign the carbonic acid to the magnesia and most of the calcium, we shall account for 30 per cent. of the analysis.

It is interesting that the remaining 70 per cent. has the composition of an albite of exceptional purity, and the only feldspar determined in the slide was albite.

SiO_2 - - -	67.89
Al_2O_3 - -	20.87
Na_2O - - -	11.24
	100.00

[1] *Loc. cit.*, p. 431.

	I.	II.	III.
SiO_2.....	53.83	60.13	51.78
Al_2O_3	16.36	20.47	12.79
Fe_2O_3.....	0.89[1]	1.04	3.59
FeO.....		.72	8.25
MgO.....	.13	1.15	7.63
CaO.....	9.81	2.59	10.70
Na_2O.....	7.89	9.60	2.14
K_2O.....	1.58	1.06	0.39
H_2O —.....	.15	.....	.63
H_2O +.....	.36	.....	.....
TiO_2.....	.86	trace	1.41
ZrO_2.....	.02	.....	.....
CO_2.....	7.47	3.44 (Ignition, includes H_2O)	.....
P_2O_5.....	.11	.....	.14
S.....	.17[2]	.....	.....
MnO.....	a little lost	trace	0.44
BaO.....	none	.....	.....
SrO.....	none	.....	.....
Li_2O	none	.....	.....
CuCu.....	.14[2]	.....	.....
	99.77	100.20	99.89

I. Analysis of Holyokeite made by Mr. Hillebrand, of the United States Geological Survey.

II. Analysis by Dr. H. S. Washington of the acid dyke in the Connecticut Trias, described by Mr. E. O. Hovey and mentioned below. *Specific Gravity* at 11° C = 2.63.

III. Analysis of the normal Triassic diabase of West Rock, New Haven, by Mr. G. W. Hawes. *Am. Jour. of Sci.*, III, IX, 186, 1875.

[1] The figure here given (0.89) includes not only ferric and ferrous iron, but also that in combination with sulphur, as (Cu FeS_2) and possibly a little FeS_2. Because of the sulphide FeO could not be estimated. (Hillebrand.)

[2] Taking the Cu as a basis the sulphides figure out 0.40 per cent. $CuFeS_2$. I cannot say that there is any FeS_2 present. The mass of the sulphide seems certainly to be chalcopyrite. (Hillebrand.)

The whole rock will then contain, roughly speaking:

Apatite	0.23
Dolomite	0.52
Calcite	16.42
Orthoclase	9.41
Albite	70.25
Ilmenite	1.63
Chalcopyrite	.40
Pyrite	.06
	100.00

This ignores the water which might have been calculated, perhaps, as kaolin, since there is no visible chloritic mineral or zeolite. It ignores also a third of a per cent. of CaO, which now forms calcite, and which with the rest of the calcium was present in the original rock, perhaps for the most part, as anorthite; that combined with the albite formed several intermediate varieties of plagioclase.

This calcium may have been present in part as a sahlite. In the latter case it might have been called a sahlite-diabase, but in a sense very different from that in which the word has been used by Törnebohm for a diabase in which the sahlite is quite subordinate to the abundant augite. The rock in which the fragments are embedded is, however, so calcareous that some part of the calcite may have been introduced into the amygdaloidal cavities from without.

The leucophyr of Gümbel is, as compared with diabase, "a remarkably light-colored rock with saussuritic feldspar, pale green augite (without hornblende and rarely with red-brown augite), with a chloritic constituent in large quantity and tabular ilmenite." This seems to me quite plainly an altered diabase, and different from this non-ferruginous rock.

The only similar rock that has been described from the American Trias is the acid dyke discovered by Mr. E. O. Hovey in the new cut on the Shore Line Railroad, in the eastern part of New Haven, provisionally referred by him to keratophyr. It is distinctly different from the type described here.[1] It is brick-red like the Cheapside trap, or grayish like the second variety described above, which accompanies the white trap.

It is largely feldspathic and the ferro-magnesian minerals are absent, but chlorite is present in considerable abundance, and the fields of chlorite and calcite "for the most part have definite outlines which strongly suggest the original presence of phenocrysts of pyroxene (augite) in the rock." Mr. Hovey remarks that spherocrystalline structure was observed in some places. This may have been the structure that I have interpreted above

[1] *Am. Jour. Sci.*, ser. 4, Vol. III, p. 287, 1897.

as a growth of secondary albite in steam holes. This suggestion depends upon a comparison with material of exceptional excellence from Cheapside where the whole process could be followed and where the perfect crystals of albite could be isolated and determined in heavy fluid. The chemical differences between the two rocks are many, as may be seen by comparing the analyses given above. In the matter of SiO_2 and Al_2O_3, the Holyokeite is intermediate between the keratophyr of Hovey and the normal diabase.

The minute quantity of iron (not enough to satisfy the S and TiO_2) and magnesia, show that there can scarcely have been a trace of augite or sahlite present in the Holyokeite, while the keratophyr may have contained much bisilicate. Finally the discrepancy in the CaO is decided, even after saturating the CO_2, and would demand, considering also the smaller amount of SiO_2, a somewhat larger proportion of anorthite in the Holyokeite, while the larger amount of K_2O would demand for it a greater amount of orthoclase or anorthoclase.

The Holyokeite may then be looked upon as representing a limiting form of the diabase series where the bisilicates are wholly wanting.

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